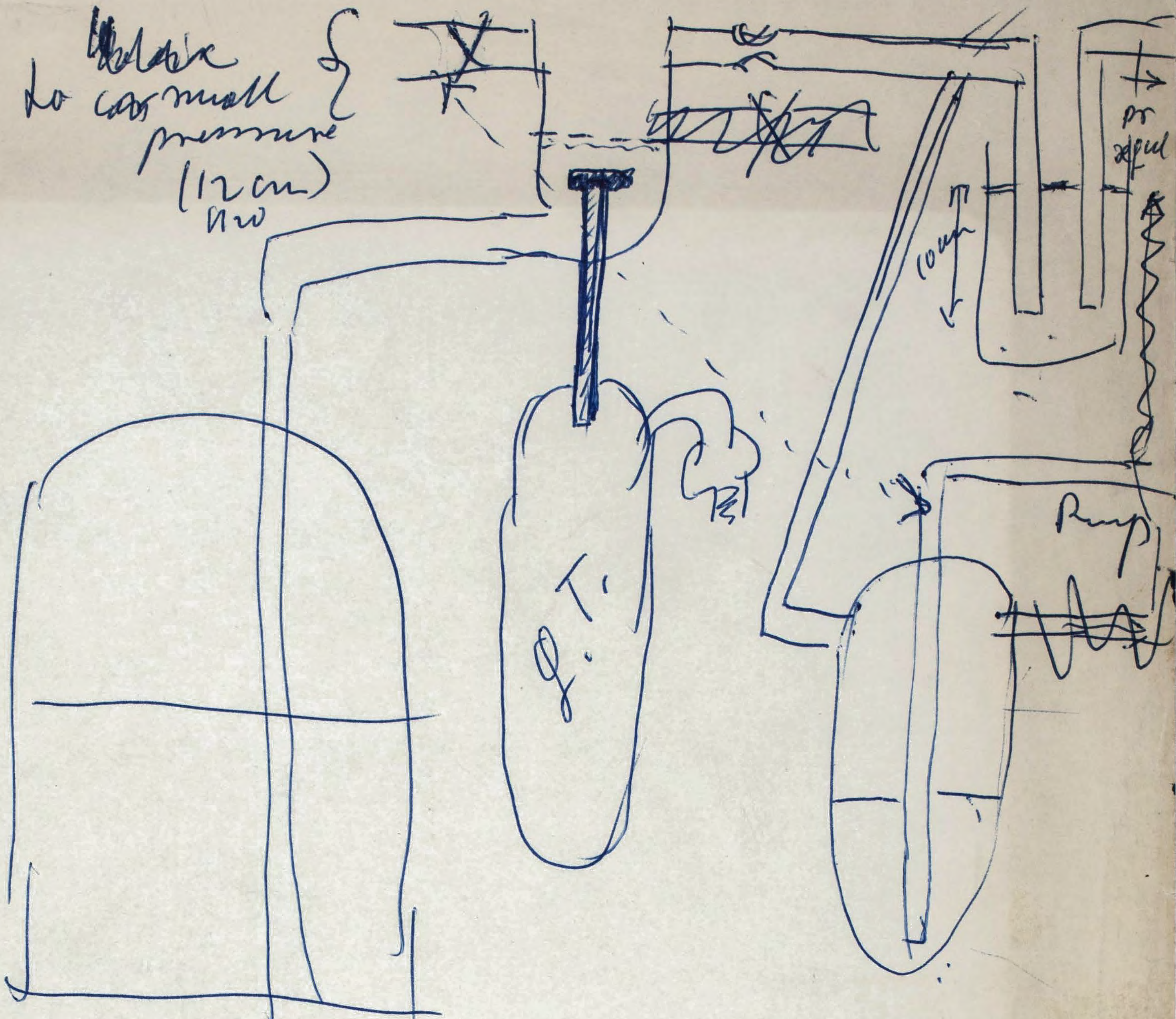
Valve to control pressure (12 cm H_2O)



— B/r is +

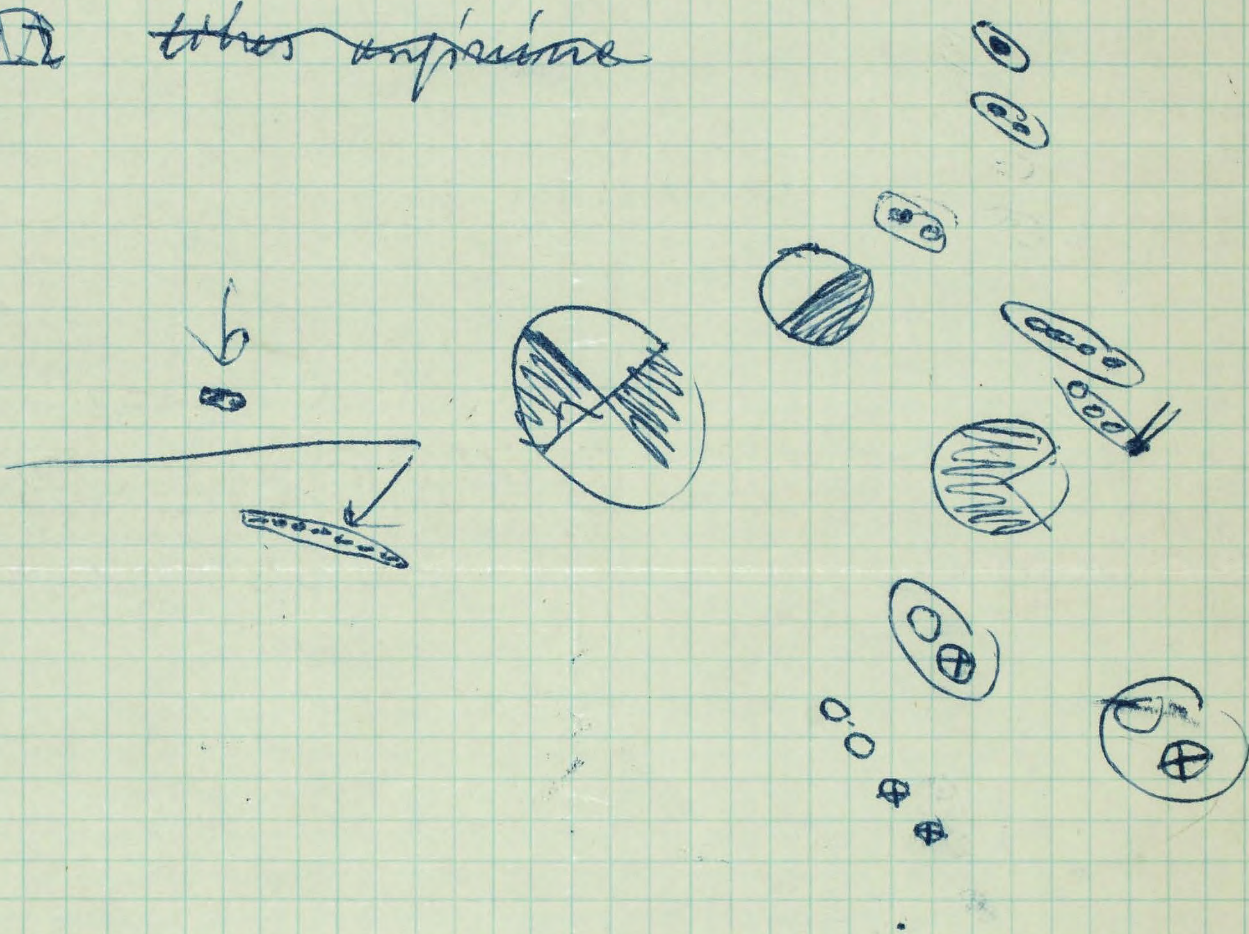
1 in 10^4 is negative [natural]
1 in 10^2 is negative. [UV] 10^{-4} survival]

soluble)
natural soluble (soluble).
after U.V. restored

~~[illegible] filter~~

12^{30} lunch

~~[illegible] tubes suspicions~~



Sd 4

Sd-4 10^8

10^5

B → B/s

Sd-4

10^8

37°

ferrous $2 - 24^{\circ}$

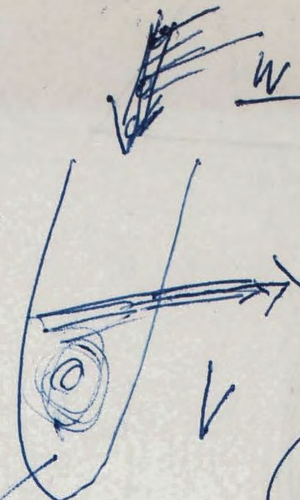
many

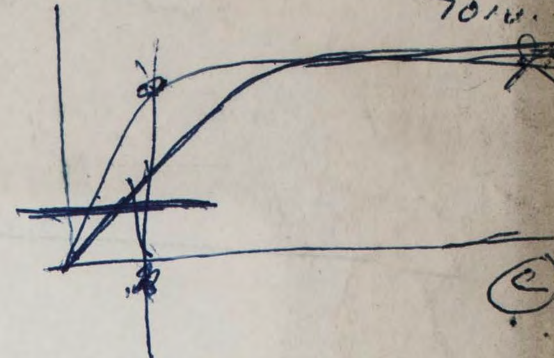
0.02%

0.02 gm in 100 cc
60 min
1800 mutants/10^8

ferrous 5 min
.0025 gm/100cc
52% survival
180/mutants/10^8 Strept
independence

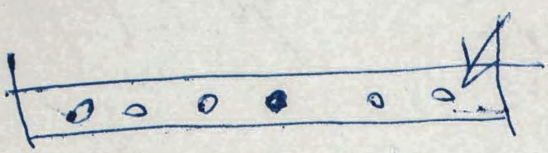
T_5



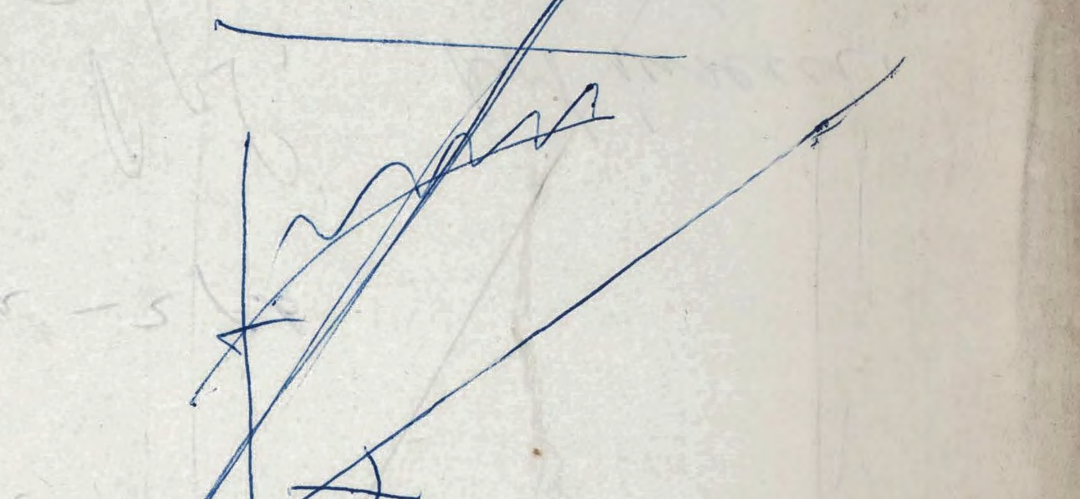


$$\frac{w}{V} > 70$$

700



$$e^{-\frac{w}{V}t}$$

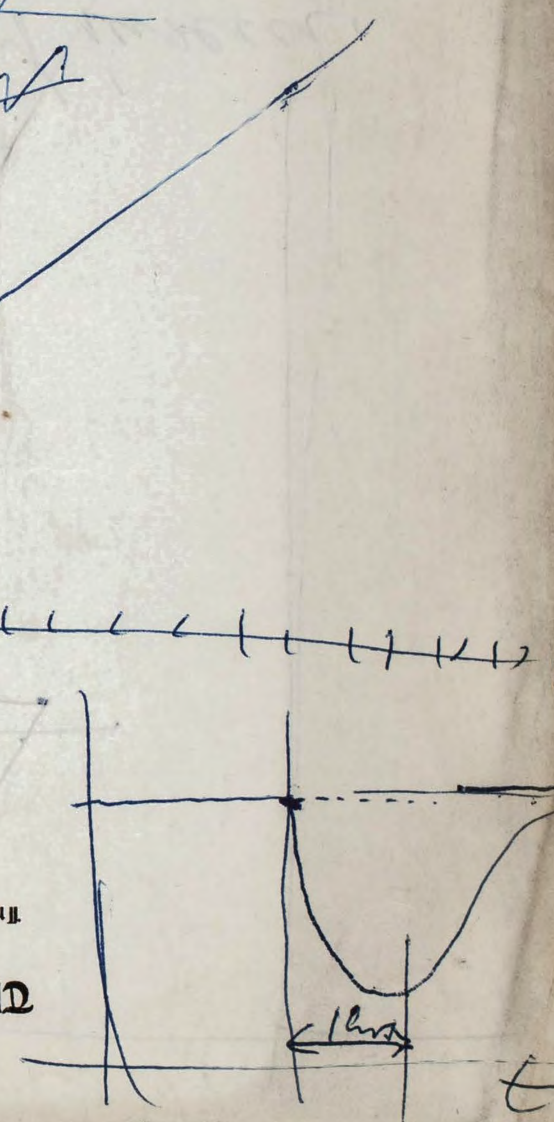


2 hr

$2.5\ 10^{-8}$

$7.5\ 10^{-8}$

$15\ 10^{-8}$



The University of Chicago
CHICAGO 37, ILLINOIS
Institute of Radiobiology and Biophysics

$\frac{dy}{dt} = a$

$\frac{dy}{dt} = \rho b$

$\frac{dq}{dt} = a - \rho b$

$\rho = \frac{b}{a}$

$\frac{dq}{dt} = 2a - 2\rho b$

Engel P.S.

Art museum.
Dept of
Anatomy

Thomas Park

Raphael Kurzrok

b

Patents ✓ 3/12/66

Transfile E

1) "1950 Paper" Biology ~~Bio~~ Dittoed.
Chemostat ~~1/4~~ Several versions. Preprint.

Notebook - Lab books.

2) Clipping. Denver Post. Jan 21, 1951
LS Joined U. Colo. Med. School. Visiting Prof. Biophysics
"Algae - 1950" Also Dio 1950.
Memorandum on growing Photosynthetic Organisms in Sunlight + Daylight. Jan 19, 1951
(Typed paper, never published.

3) Microbial Genetics Bulletin. #6. April 1952
Cold Spring Harbor.

4) Cold Spring Harbor course Notebook. Aug. ?
Laboratory Manual, 1947 Bacteriophage
by Delbruck & Adams.

5) "Microscopes." 1953, equipment catalogs.

6) Biology. Freezing of bull sperm 1952, (with Fox)

7) Biology Bull sperm freezing. Biology low temperature. Data, 1953. Includes bibliography. Photos

8) "Aging" Calculations

9) "Age". Notebook with calculations.
References & notes.

"Fan"
E
2

Stalin letter

10) Clipping. Wash Post 11/25/47.
"Scientists' Appeal to Stalin Balked"
Includes letter from school children & answer by L.S.
Christmas cards 1947.
Correspondence re Stalin from public.

11) ~~Biology: Notes~~ "Library": biological References.
Includes List of books borrowed from biology Library

12 Misc. Found loose,
Some bio notes, Reprints, Abstracts
Removed, Renumbered E-40

~~Means~~ Brachenwal [illegible] Salter

Dr. Nitrowsky 269

U_t excreted up to $t = t$

$$\frac{dU}{dt} = k_u C$$

$$-\frac{dc}{dt} = k_T C + k_{unive} C$$

$$C = \frac{C_0 e^{-(k_T + k_u)t}}{k_T + k_u}$$

$$\frac{du}{dt} = \frac{k_u}{k_T + k_u} C_0 e^{-(k_T + k_u)t}$$

0.05 normal
0.12
0.1 – 0.3
25
micrograms

Ice group of hydro [illegible]

0.01 mgm } in test

24 grains = 1.5 gm

1 grain = 0.06 gm = 60 mgm

(400)

$$\ln \frac{du}{dt} = \ln \frac{k_u C_0}{K_T + K_u} - (K_T + k_u)\, t$$

thyroid 200 mgm dry gland
thyroxine

0.23%

$200 \times \frac{2}{1000}$

$\frac{4}{10}$ mgm I

Means
page 66

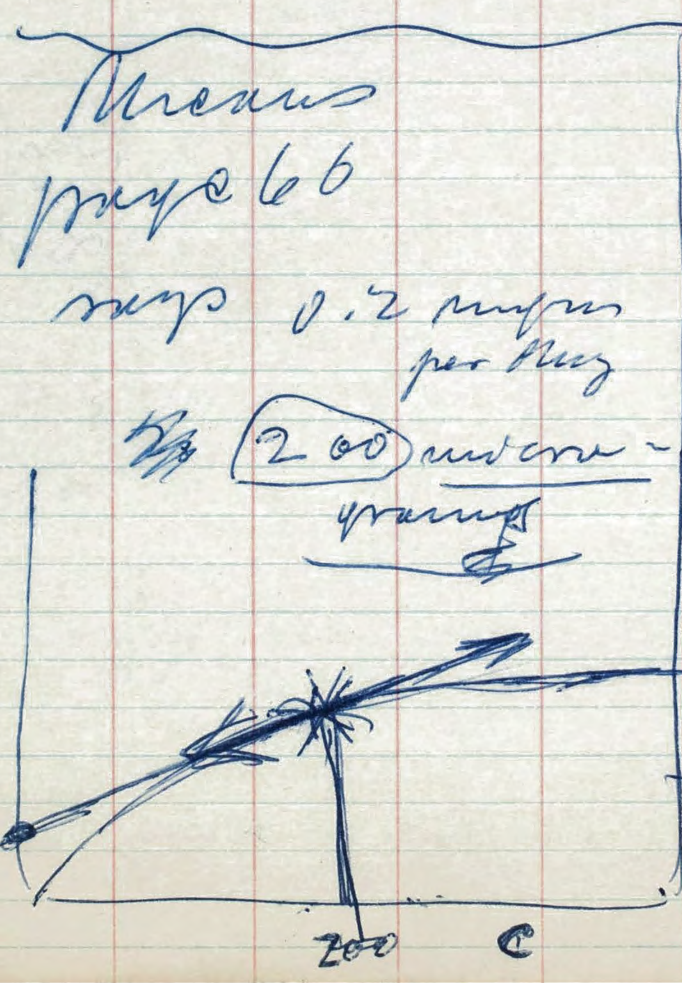
says 0.2 mgm
per day

200 micrograms

20 to 80 micrograms
per day

Book gives 108

1.3% 1 cc = 13 mgm



65 times
simply require $\frac{1.3}{\text{meat }100}$ gm

~~19 gm in 100 cc~~

1:16

19 gm in 100 cc

Iodized salt [1 part of NaI to 10⁵ of salt]

Fellner says
15 to 40 γ /day

(2 gms per day) = 20 γ /day

minimum requirement

Dr Corbell Mr Wyler

Sp 2717 || M 134

$f(n-1)\ f(n)\ f(n+1)$

other smaller strand

$$\frac{df(n)}{dt} = \left[f(n) e^{-\beta n} + \cdots \right] \frac{\lambda}{2} - k f(n)$$

$e^{-\beta n}$

$$\frac{df(n)}{dt} = \bar{a}\, f(n) - k\, f(n)$$

$e^{-\beta n}$

$$\sum_{0}^{n} \frac{1}{2} f(n-K)\, f(n+K)\, \cancel{f(n,0)} + k\, f(n-1) - k\, f(n) = \bar{a}\, f(n)$$

$f(n) e^{-\beta n}$ ... $f(n-1)$ ...

$f(n)\,[\bar{a} + 2 + e^{-\beta n}] = k\, f(n-1)$

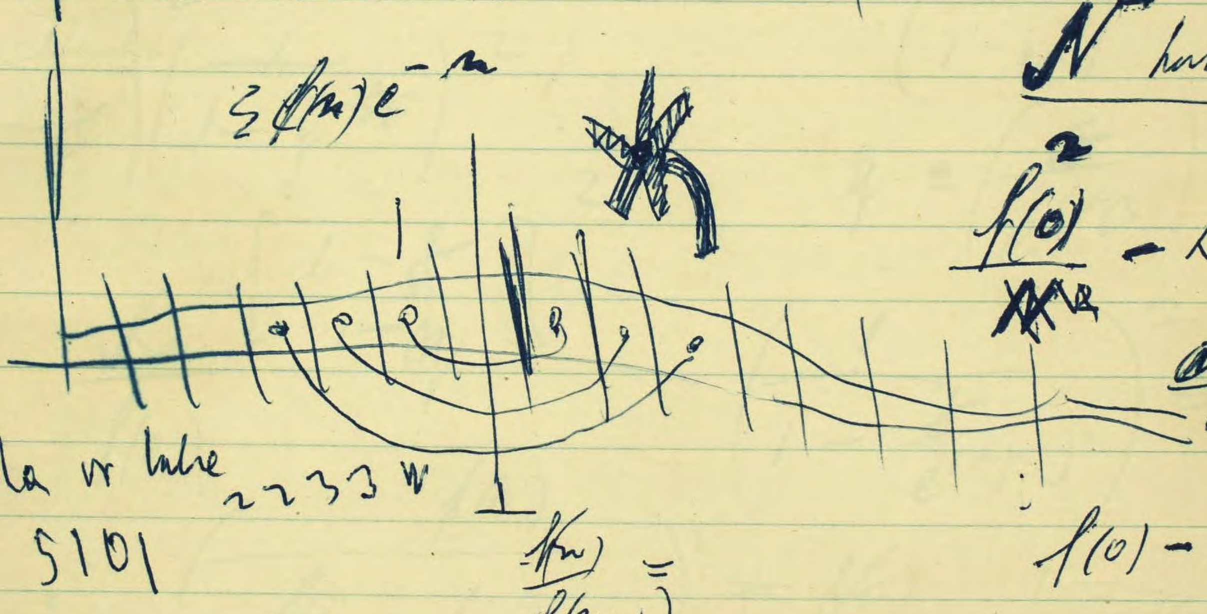
$$\frac{f(n)}{f(n-1)} = \frac{k}{f(0)}$$

$f(n) = \cancel{\quad} \ \delta^{n}$

$$\frac{\delta^{+n-K}\ \delta^{n+K}\ e^{-\beta n}}{N^2}$$

N natural number

$\sum f(n) e^{-n}$



$$\frac{f(0)^2}{\cancel{N}} - k f(0) = \bar{a} f(0)$$

$$\frac{df(n)}{dt} = \bar{a}\, f(n)$$

Ma vr lubre 2233 W

5101

$$\frac{f(n)}{f(n-1)} =$$

$f(0) - k = \bar{a}$

$$f(0) = \sum_{i,k} f(i) f(k)\, e^{-(i+k)\beta}\, e^{-i+k}$$

$$\delta^i\, \delta^k$$

$$\delta^{i+k}\, e^{-(i+k)}\, e^{-(i+k)\beta}$$

$$\sum_{ik} \left[\cancel{\delta}\, e^{-(1+\beta)} \right]^{i+k} = f(0)$$

$$\sum_{ik} \left(\frac{\delta}{e^{(1+\beta)}} \right)^{i+k}$$

$$1 + q + q^2 + q^3 \ldots$$

$$\sum_{ik} A^{i+k}$$

$$A \left[A^0 + A^1 + A^2 \right] = A \left[\frac{1}{1-q} \right]$$

$$+ \; A^2 [$$

$$A^3 [\; \cdots$$

$$\left(\frac{1}{1-\delta} \right)^2 \left(\frac{1}{1-\rho} \right)^2$$

$$\left(\frac{1}{1-q} \right)^2 \sum$$

$$q = \left(\frac{\delta}{e^{1+\beta}} \right)$$

$$\frac{\lambda}{f(0)} \left[\frac{1-\delta}{1-q} \right]^2$$

$$\left(\frac{1}{1 - \frac{\delta}{e^{1+\beta}}} \right)^2 = f(0)$$

$$\left(\frac{f(0)}{\frac{f(0)}{A(\lambda)} - \frac{\lambda}{A(\lambda)} \frac{1}{e^{1+\beta}}} \right)^2 = f(0) \qquad r = \frac{f(0)}{f(0) - \lambda \frac{1}{e^{(1+\beta)}}}$$

$$1 = \frac{f(0)}{f_0 - \lambda \frac{1}{e^{(1+\beta)}}}$$

$$f(0) - \lambda e^{-(1+\beta)} = f(0)$$

$$1 = \lambda e^{-(1+\beta)}$$

$$\lambda = e^{1+\beta}$$

$\bar{a} = \frac{1}{10}$

$\frac{\lambda}{\lambda + \frac{1}{10}} < 1$

$\bar{a}$

$\lambda < \lambda + 1/10$

$\boxed{f < 1 \quad \frac{\lambda}{\bar{a} + \lambda} < 1}$

$\lambda \le f(0)$

$$\frac{f(0)}{\left[f(0) - \lambda e^{-(1+\beta)}\right]^2} = 1$$

$\frac{1-f}{\beta} = \bar{a} + \lambda$

$\frac{\lambda}{\bar{a} + \lambda} = f$

$1 - \frac{\lambda}{\bar{a} + \lambda} = \beta(\bar{a} + \lambda)$

$\bar{a} + \cancel{\lambda - \lambda} = \beta(\bar{a} + \lambda)^2$

$$f(0) = f(0)^2 - 2\lambda e^{-(1+\beta)} f(0) - \lambda^2 e^{-2(1+\beta)}$$

$$0 = f(0)^2 - \left[2\lambda e^{-(1+\beta)} + 1\right] f(0) \lambda^2 e^{-2(1+\beta)}$$

$$0 = 1 - \left[2\frac{\lambda}{f(0)} e^{-(1+\beta)} + 1\right] - \left(\frac{\lambda}{f(0)}\right)^2 e^{-2(1+\beta)}$$

$$\left[\frac{1-f}{1 - \frac{f}{e^{1+\beta}}}\right]^2 \quad \frac{(1-f)\, e^{1+\beta}}{e^{1+\beta} - f} \quad (\bar{a} + \lambda) f(0)$$

Effect of more than one offspring (n_1)

$$\Delta f(n) = m f(n) e^{-\beta n} + \lambda m e^{-\beta(n-1)} f(n-1) - \lambda m f(n)$$

($f(n)$ number of bacteria with born with n mutations in them in n generations

$\Delta f(n)$ increase in $n+1$ generations

$$\Delta f(n) = \bar{a} f(n)$$

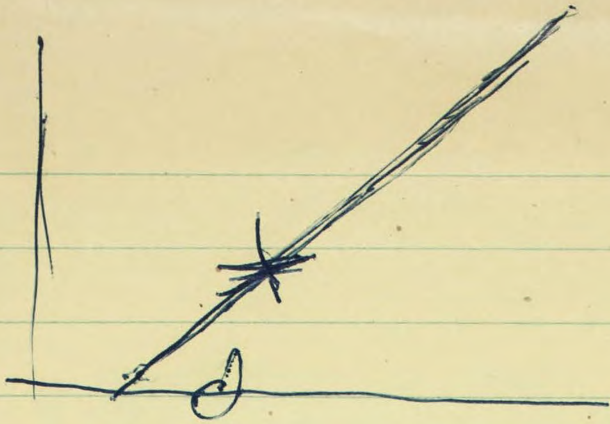
$$\bar{a} f(n) = m f(n) e^{-\beta n} - \lambda m e^{\beta n} + \lambda m e^{\beta} e^{-\beta n} f(n-1)$$

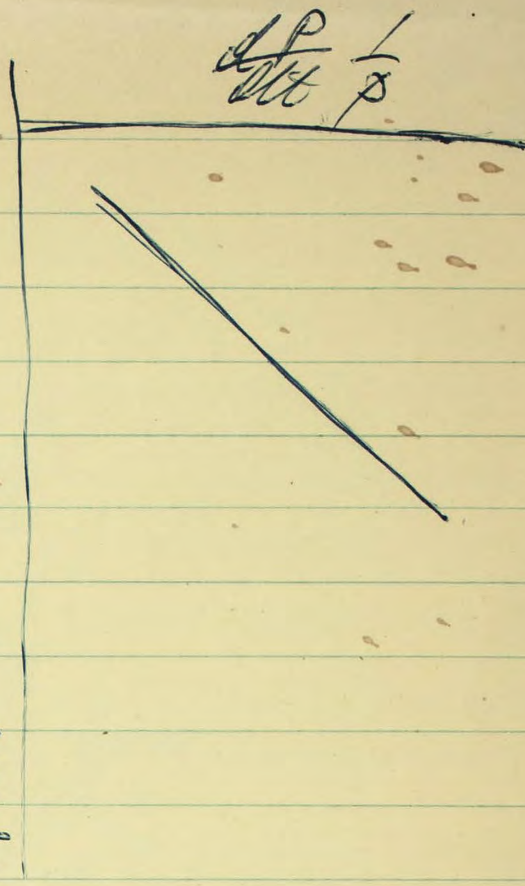
$$e^{\beta n} \bar{a} f(0) = m f(0) - \lambda m f(0)$$

$$\bar{a} + \lambda m = m$$

$$(\bar{a} - m e^{-\beta n} + \lambda m) f(n) = \lambda m e^{\beta} e^{-\beta n} f(n-1)$$

$$\frac{f(n)}{f(n-1)} = \frac{\lambda m e^{\beta} e^{-\beta n}}{\bar{a} - m e^{-\beta n} + \lambda m} = \frac{\lambda e^{\beta} e^{-\beta n}}{1 - e^{-\beta n}}$$





Katalase in → Phys Chem
ter Meulengracht

Rehberg   Physiology

~~Cast~~
Linderstrøm Lang } Carlsberg Laboratories
Holter

[illegible]

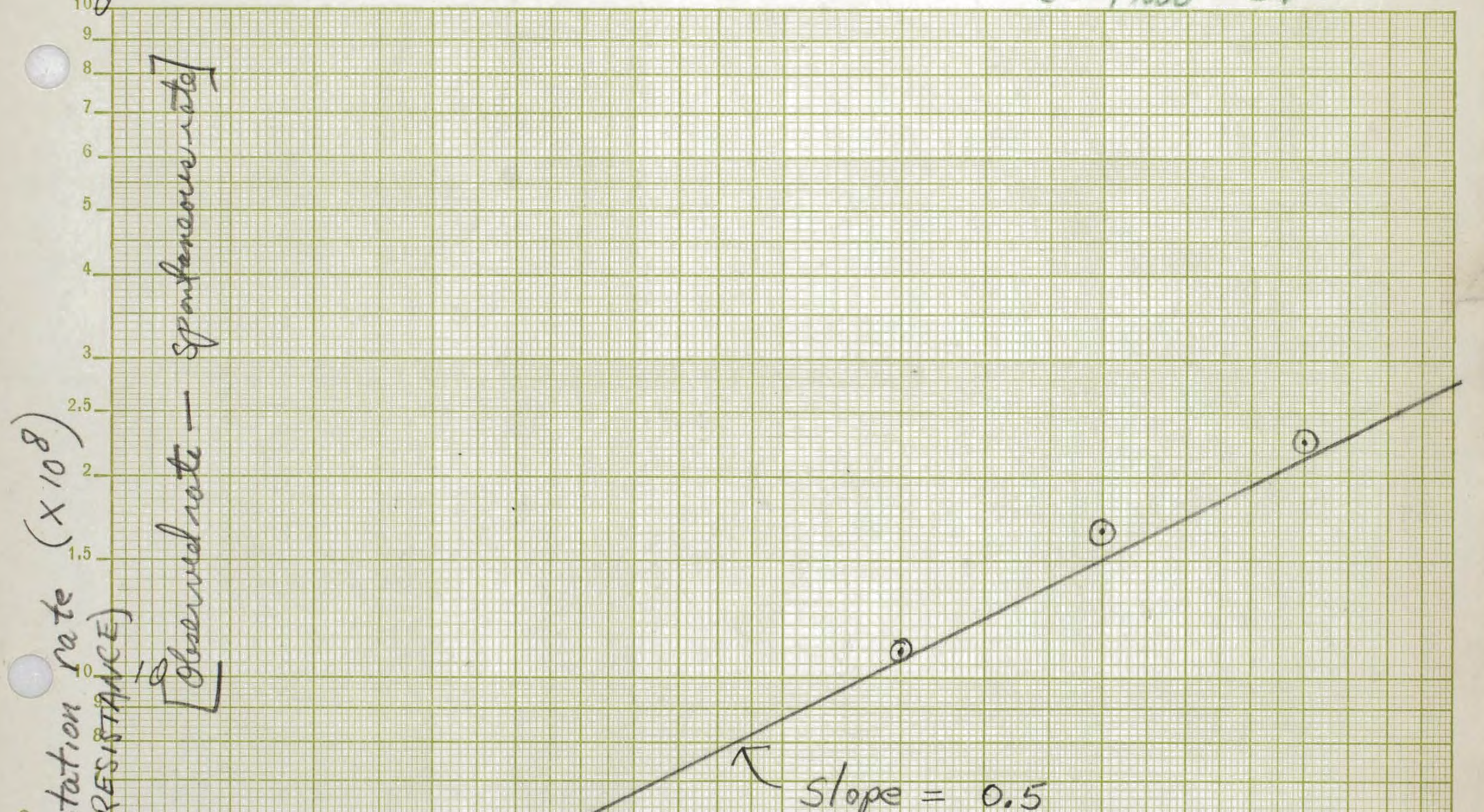
~~Ast~~
Fischer   Biological Inst
of the Carlsberg Foundation

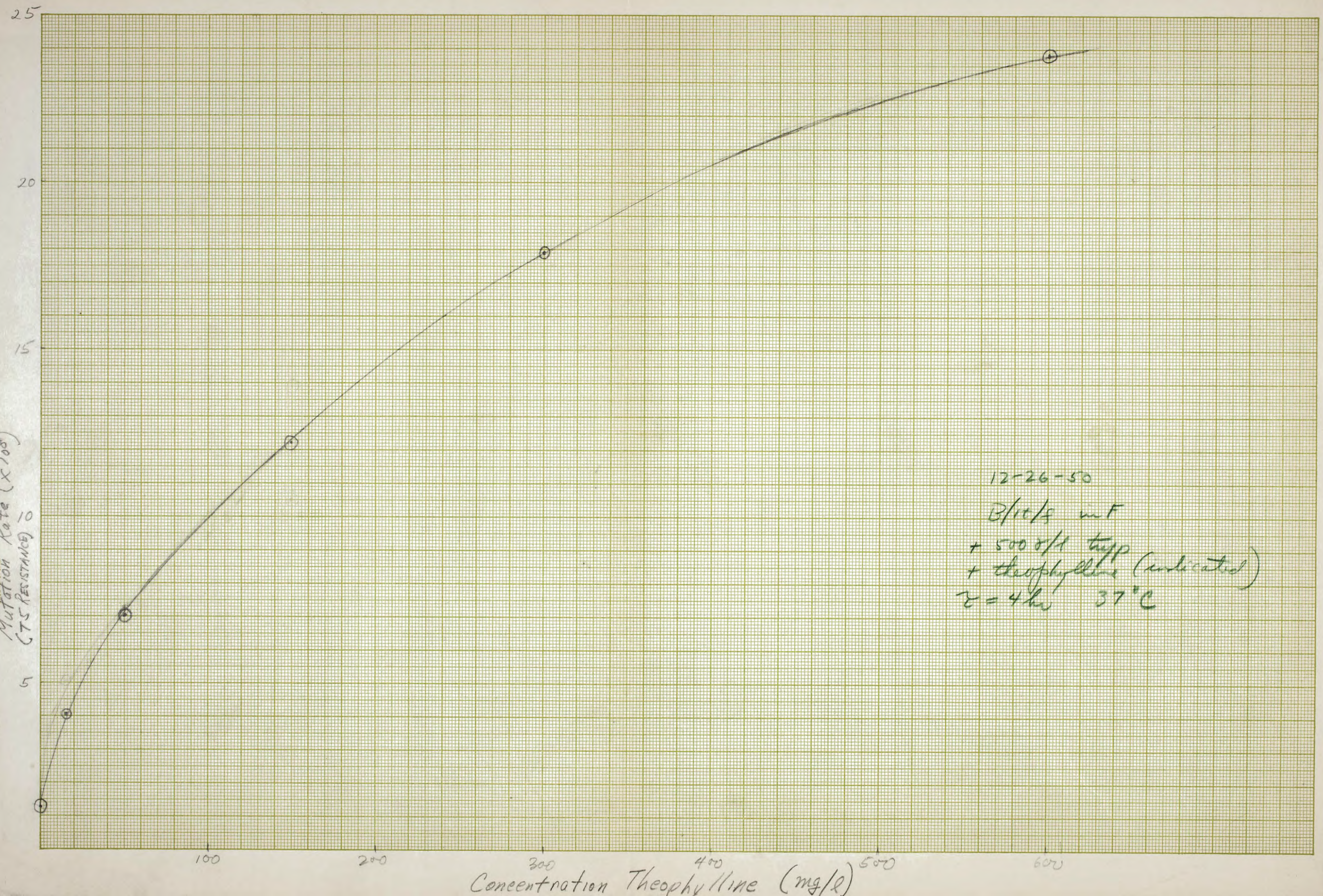
Wenner-Gren Inst.   Stockholm
→ Brunnström (Chem. [illegible])
Caspersson

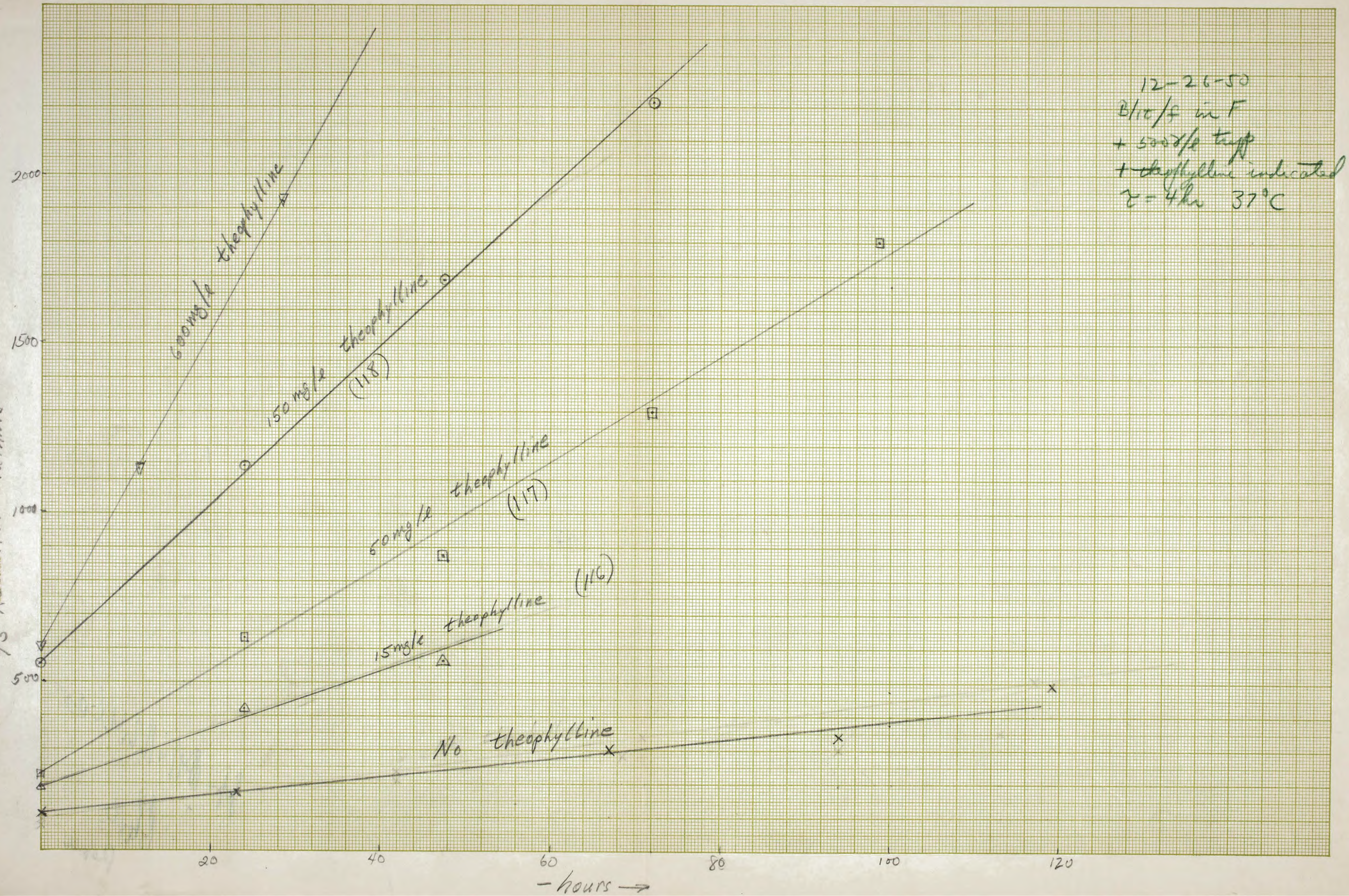
Uppsala

Kerstadius Exp. of Zool.
Sen Unbron-Eggs

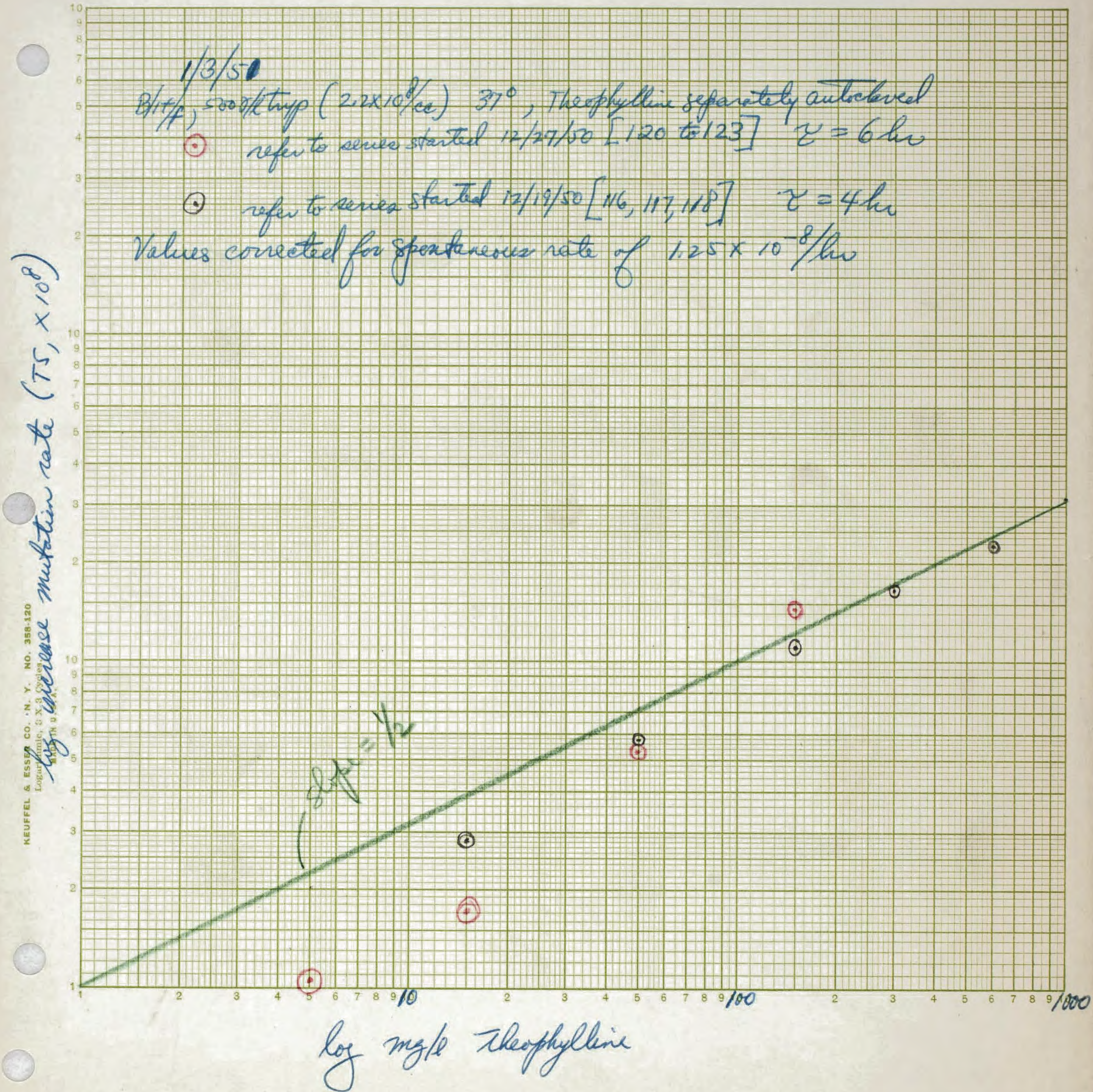
12-26-50
B/10/min +
+ 500γ/l tryp
+ theophylline indicated
τ = 4 hr 37°

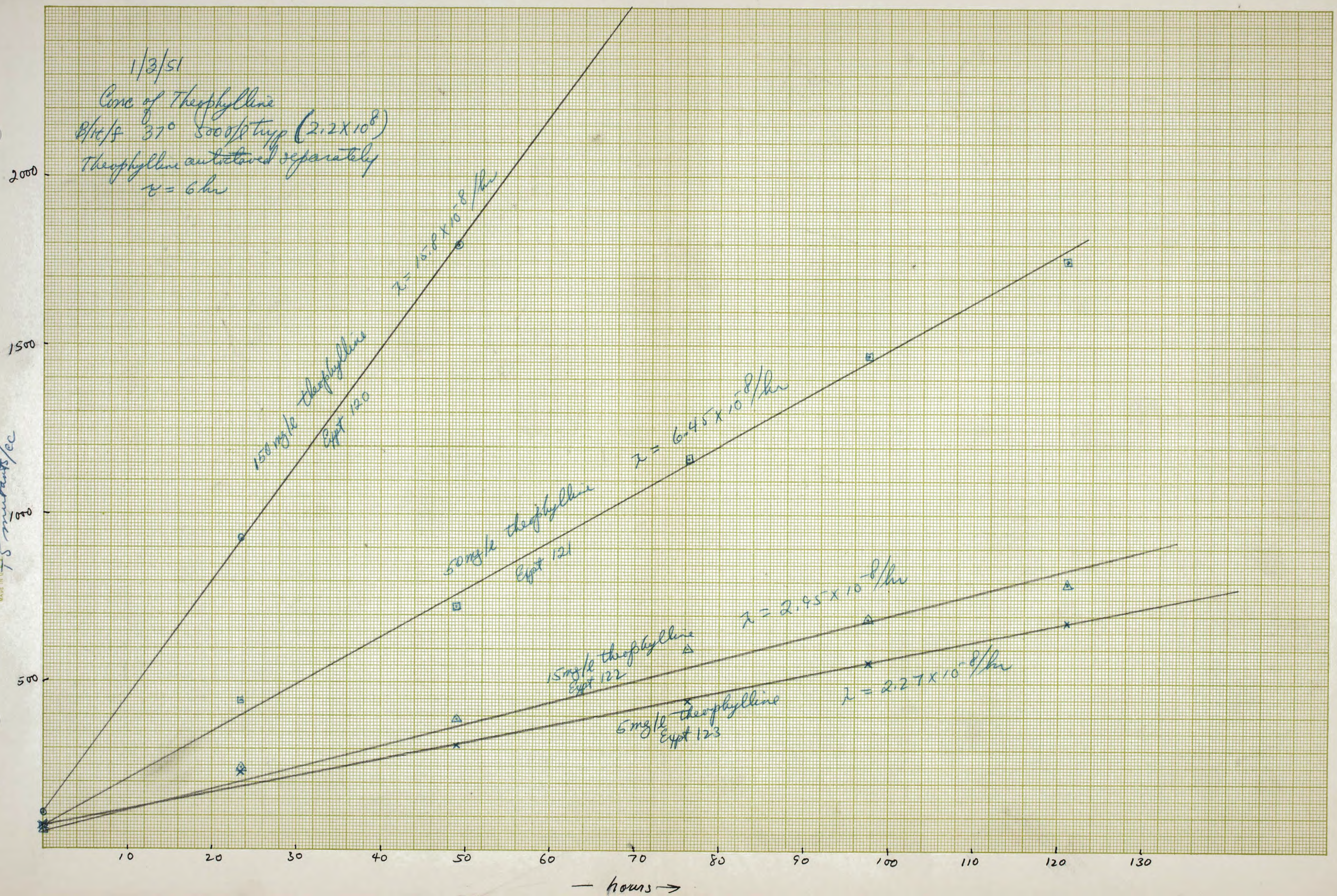



25
20
15
10
5
100
200
300
400
500
600
Mutation Rate (x 10⁸)
(T5 RESISTANCE)
Concentration Theophylline (mg/l)
12-26-50
B/r/f mF
+ 500 γ/l tryp
+ theophylline (indicated)
τ = 4 hr 37°C

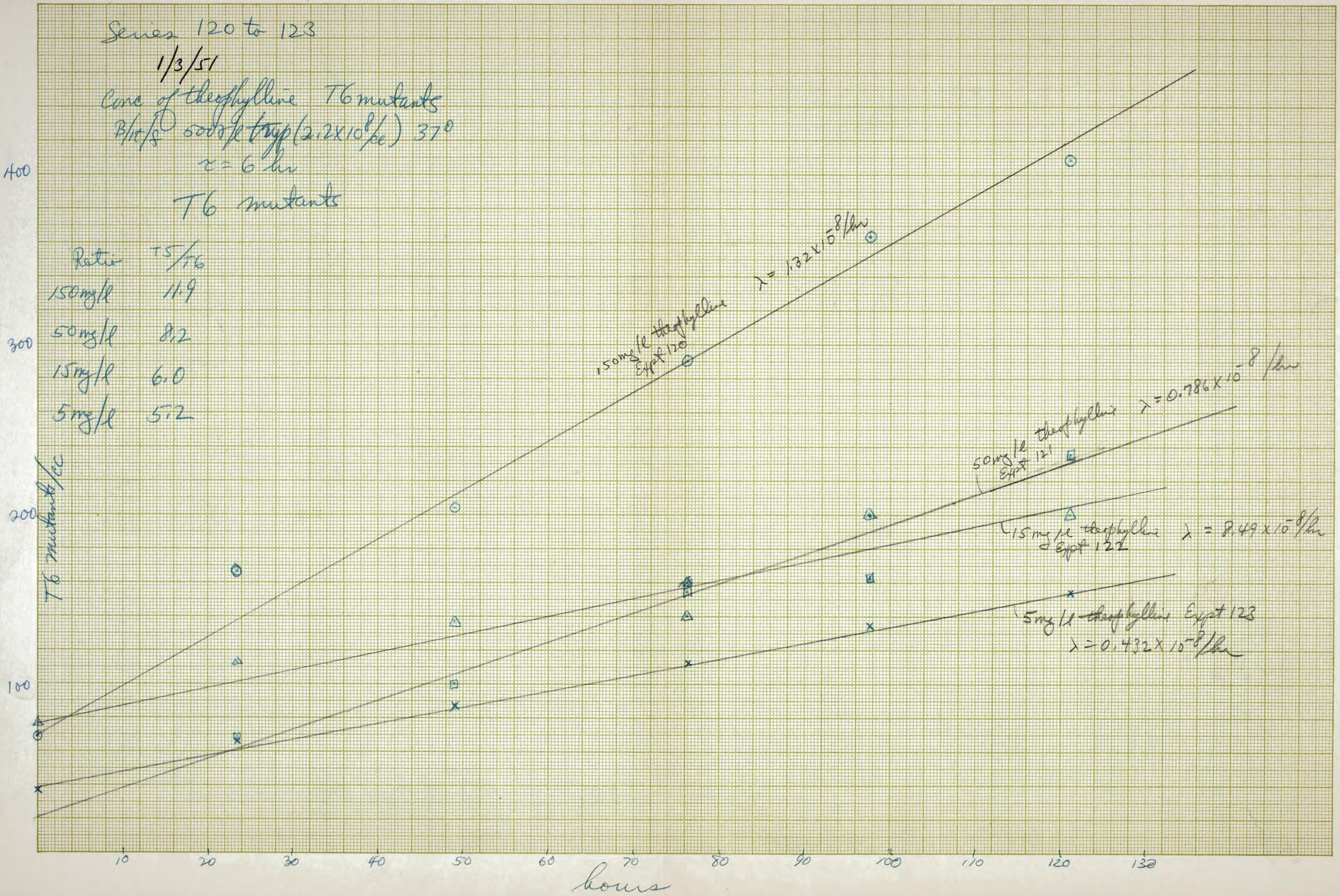

12-26-50
B/r/f in F
+ 500γ/l tryp
+ theophylline indicated
τ = 4hr 37°C
T5 RESISTANT MUTANTS PER CC
2000
1500
1000
500
600mg/l theophylline
150 mg/l theophylline
(118)
60mg/l theophylline
(117)
(116)
15mg/l theophylline
No theophylline
20
40
60
80
100
120
- hours →

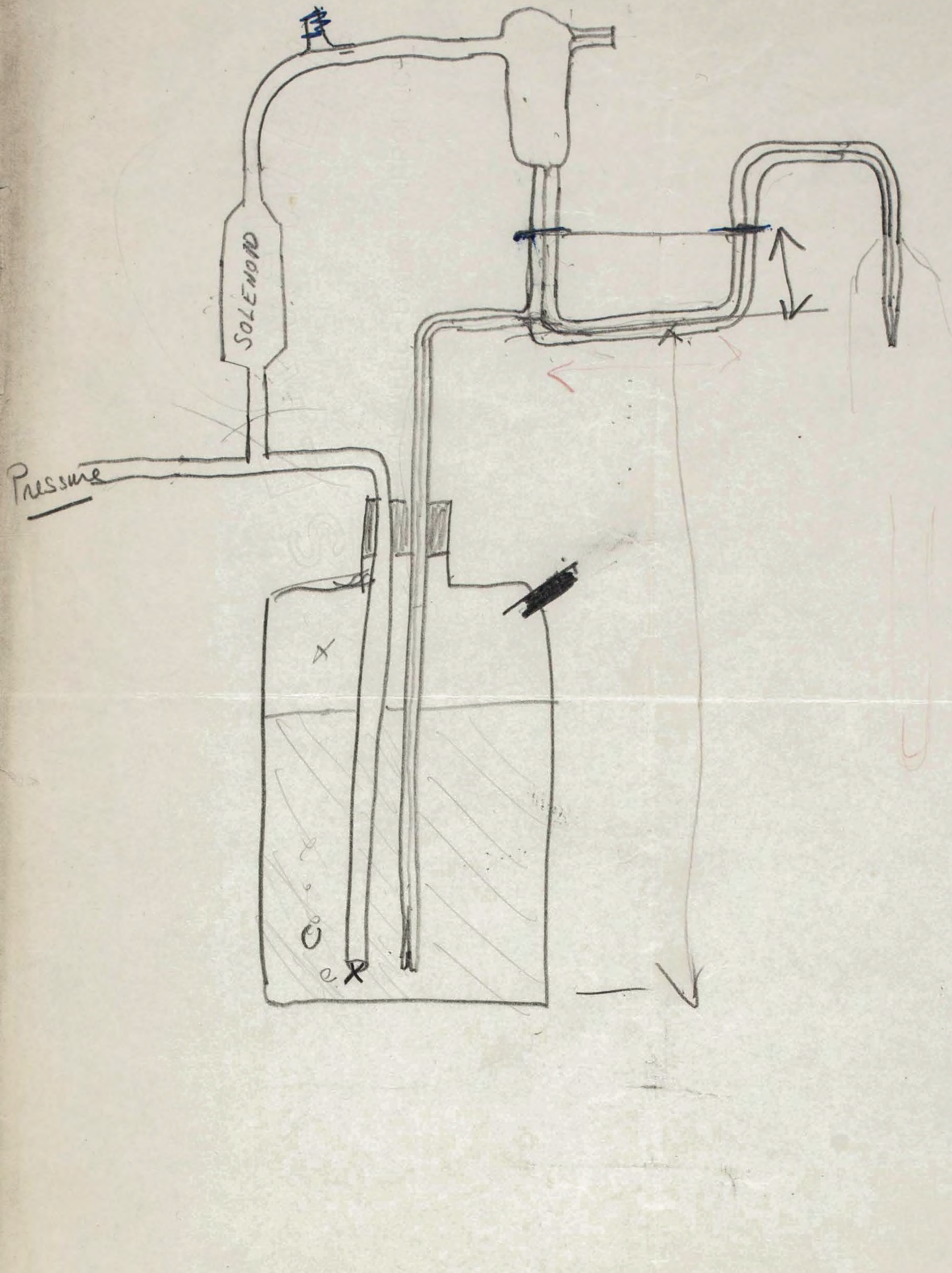
H. M. Muller
Chile
Repub

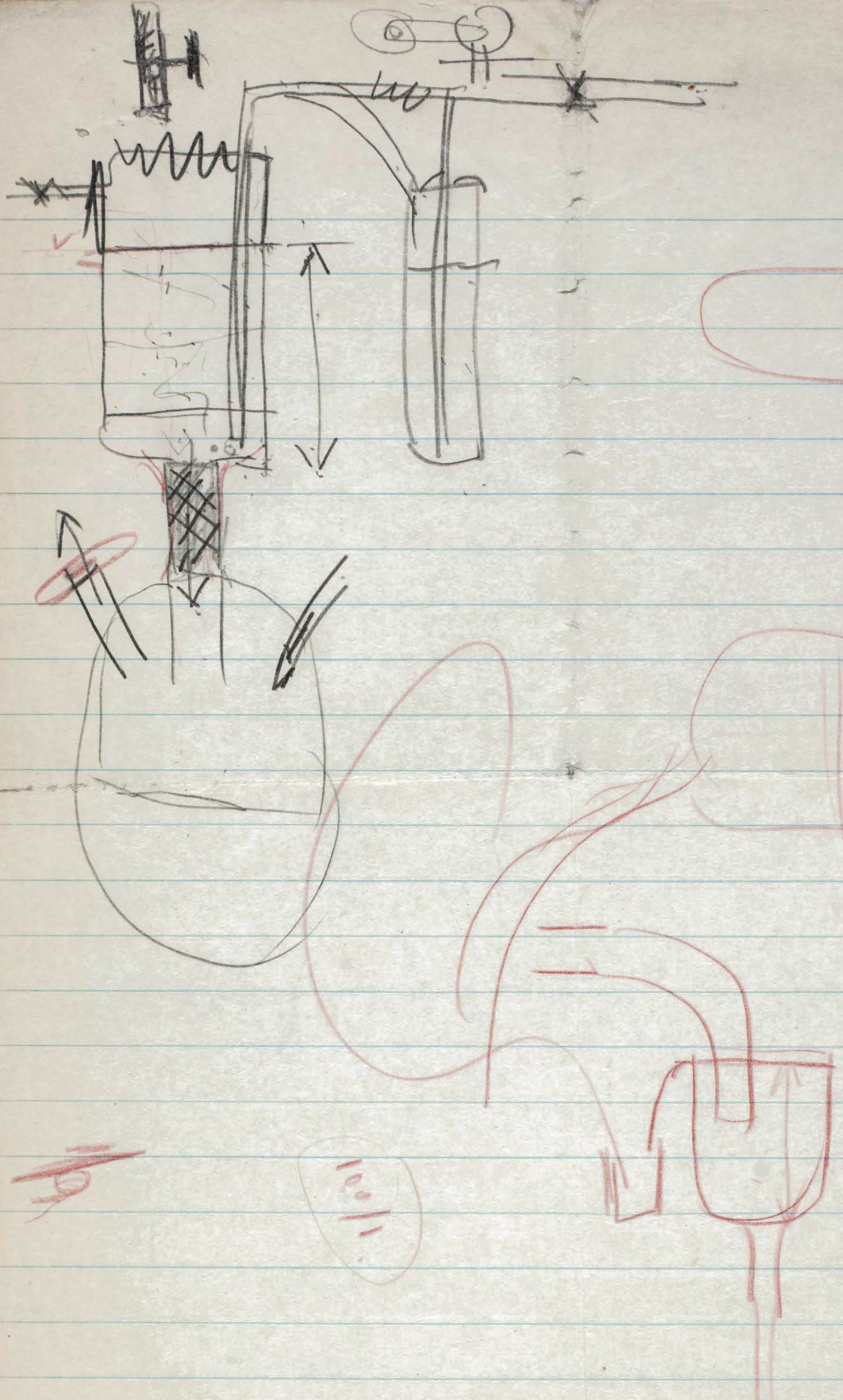

1/3/51
B/1+/F), 5007k tryp (2.2x10^8/cc) 37°, Theophylline separately autoclaved
refer to series started 12/27/50 [120 to 123] τ = 6 hr
refer to series started 12/19/50 [116, 117, 118] τ = 4 hr
Values corrected for spontaneous rate of 1.25 x 10^-8/hr
Slope = 1/2
log increase mutation rate (T5, x 10^8)
log mg/l Theophylline
10
100
1000
KEUFFEL & ESSER CO. N. Y. NO. 358-120
Logarithmic, 3 X 3 Cycles
MADE IN U.S.A.

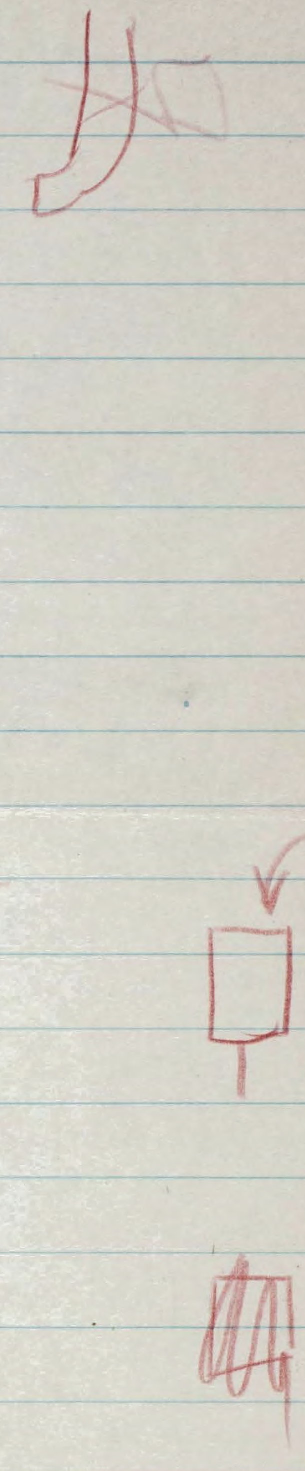


1/3/51
Conc of Theophylline
B/ht/f 37° 5000/l tryp (2.2X10^8)
Theophylline autoclaved separately
τ = 6 hr
λ = 16.8 × 10^-8/hr
150 mg/l theophylline
Expt 120
λ = 6.45 × 10^-8/hr
50 mg/l theophylline
Expt 121
λ = 2.45 × 10^-8/hr
15 mg/l theophylline
Expt 122
λ = 2.27 × 10^-8/hr
5 mg/l theophylline
Expt 123
T5 mutants/cc
500
1000
1500
2000
10
20
30
40
50
60
70
80
90
100
110
120
130
— hours →


Series 120 to 123
1/3/51
Conc of theophylline T6 mutants
B/r/s 5000/l tryp (2.2x10^8/cc) 37°
τ = 6 hr
T6 mutants
Ratio T5/T6
150mg/l 11.9
50mg/l 8.2
15mg/l 6.0
5mg/l 5.2
150mg/l theophylline Expt 120
λ = 1.32x10^-8/hr
50mg/l theophylline Expt 121
λ = 0.786x10^-8/hr
15mg/l theophylline Expt 122
λ = 0.49x10^-8/hr
5mg/l theophylline Expt 123
λ = 0.432x10^-8/hr
T6 mutants/cc
100
200
300
400
10
20
30
40
50
60
70
80
90
100
110
120
130
hours
359-14L KEUFFEL & ESSER CO.
Millimeters, 5 mm. lines accented, cm. lines heavy.
MADE IN U.S.A.


SOLENOID
Pressure



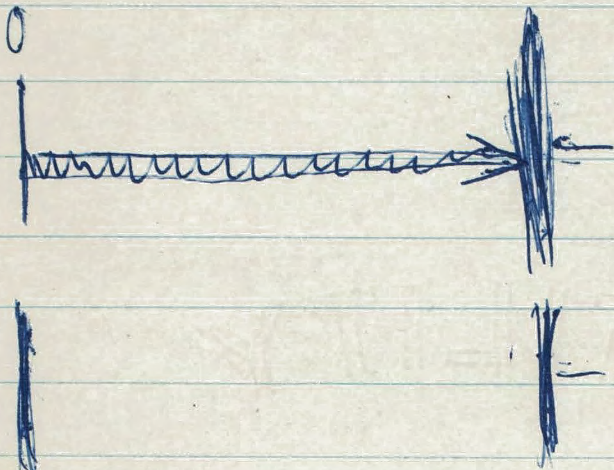


1/50 cc

e^{23}

$f(x)$

$\boxed{x = d}$



Ebars

10 years

30 kcal / day kg

40 times

3000 kg mayor

$\frac{1}{100}$ kg mayor / kg day

~~Plan~~ 120

1 kg

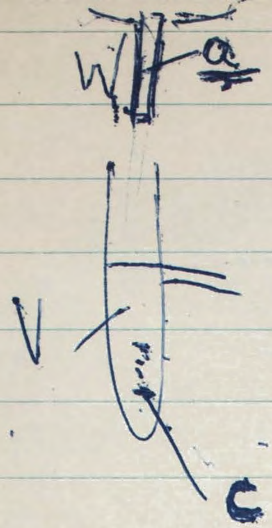
75 kg

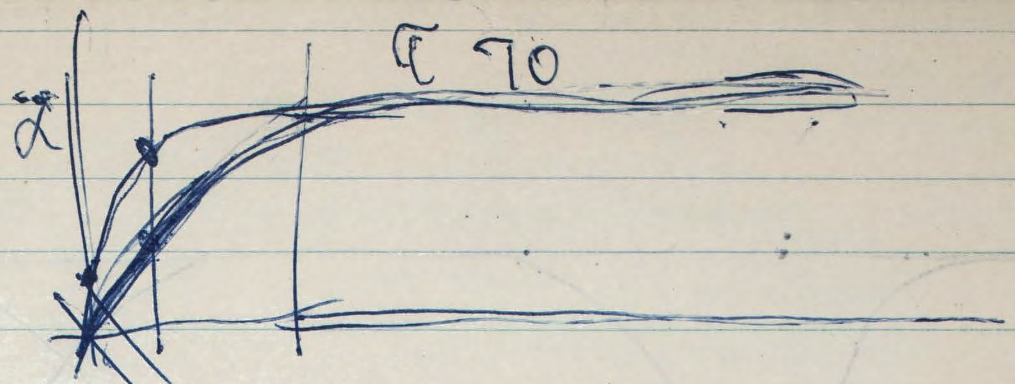
$\boxed{7,500}$

20 ~~min~~ x 7500 min

$\frac{60.00}{4} = 150$

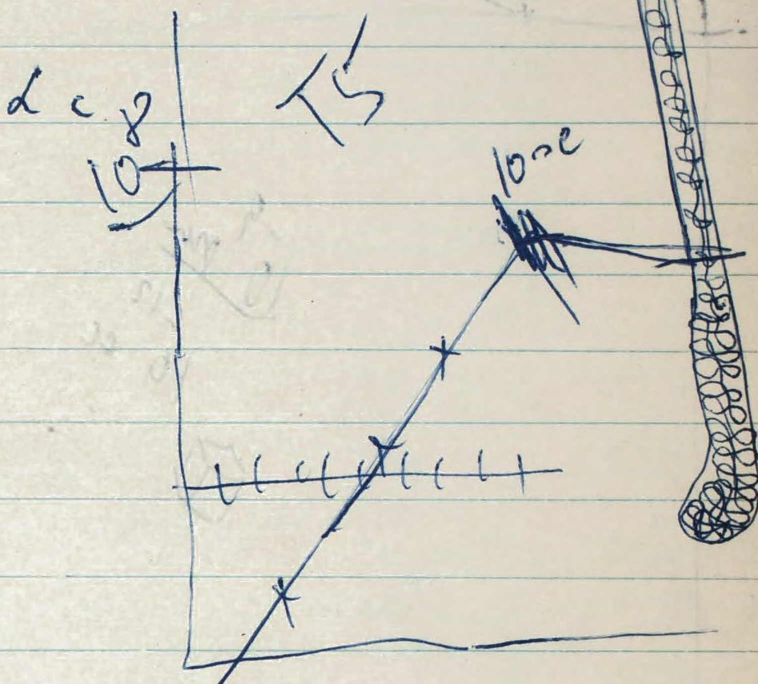
150 10^{3} min = 100





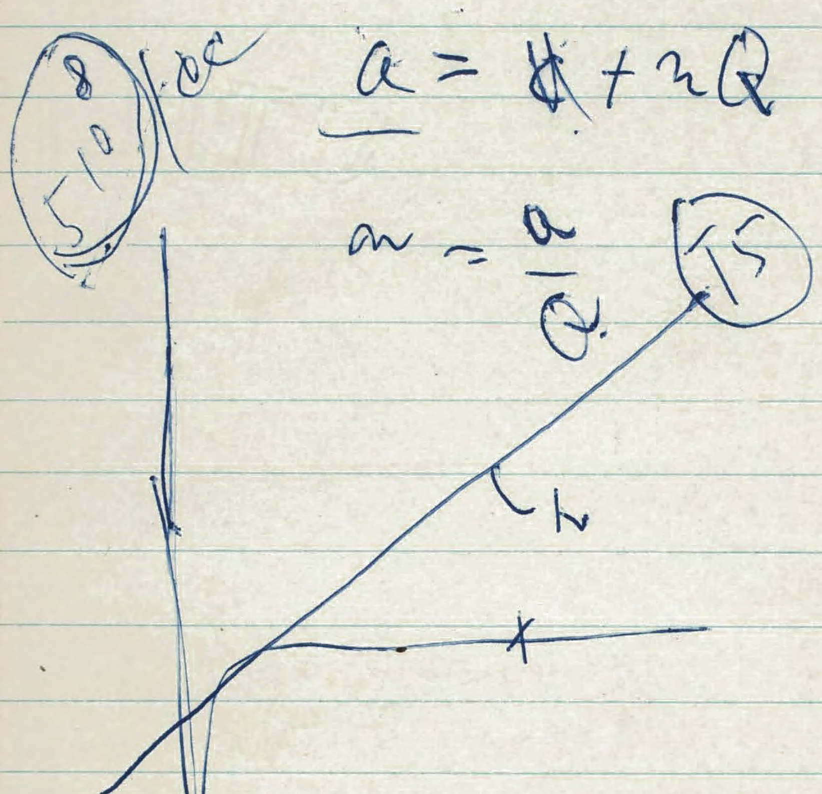
$$e^{-\frac{W}{V}t}$$

$$e^{\alpha(c)t}$$



$$a = \cancel{a} + 2Q$$

$$a = \frac{a}{Q}$$



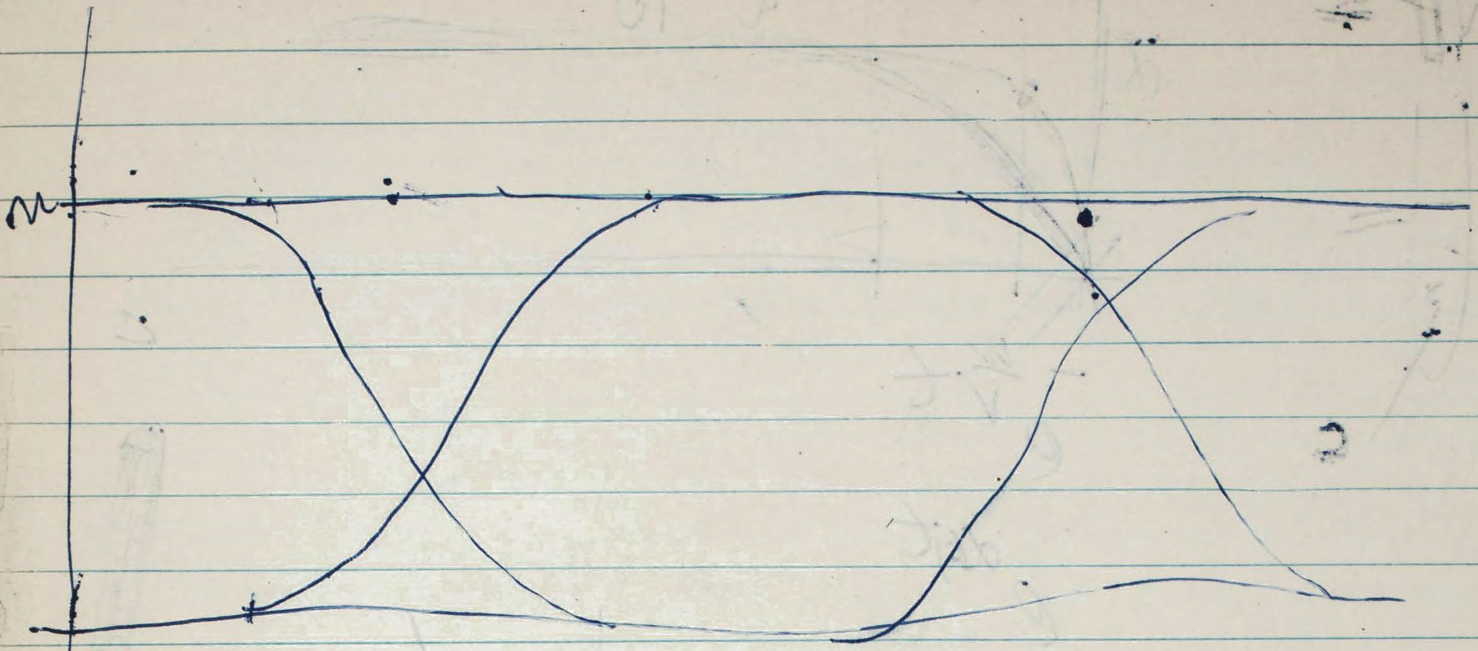
$$k = A\, e^{-\frac{W}{RT}}$$

$A = 10^{-3}$ /sec.

$A = 10^{14}$ /sec

$A = 10^{5}$

10^{15} /sec



$$\frac{10^{-9}\ \text{gm}}{10^{-12}\ \text{cc}}$$

$$\frac{d\, f(\lambda, t)}{dt} = c f(\lambda, t)$$

$$\frac{d}{dt} f(\lambda, t) = (\alpha + \beta\lambda) f(\lambda, t)$$

$$(\alpha + \beta\lambda) \cancel{f(\lambda, t)} = c f(\lambda, t)$$

$$(\alpha + \beta\lambda) = c$$

Consider $\sum_{k+l=n} f_1(k) \lambda^k f_1(l) \lambda^l$

This is n th coeff λ

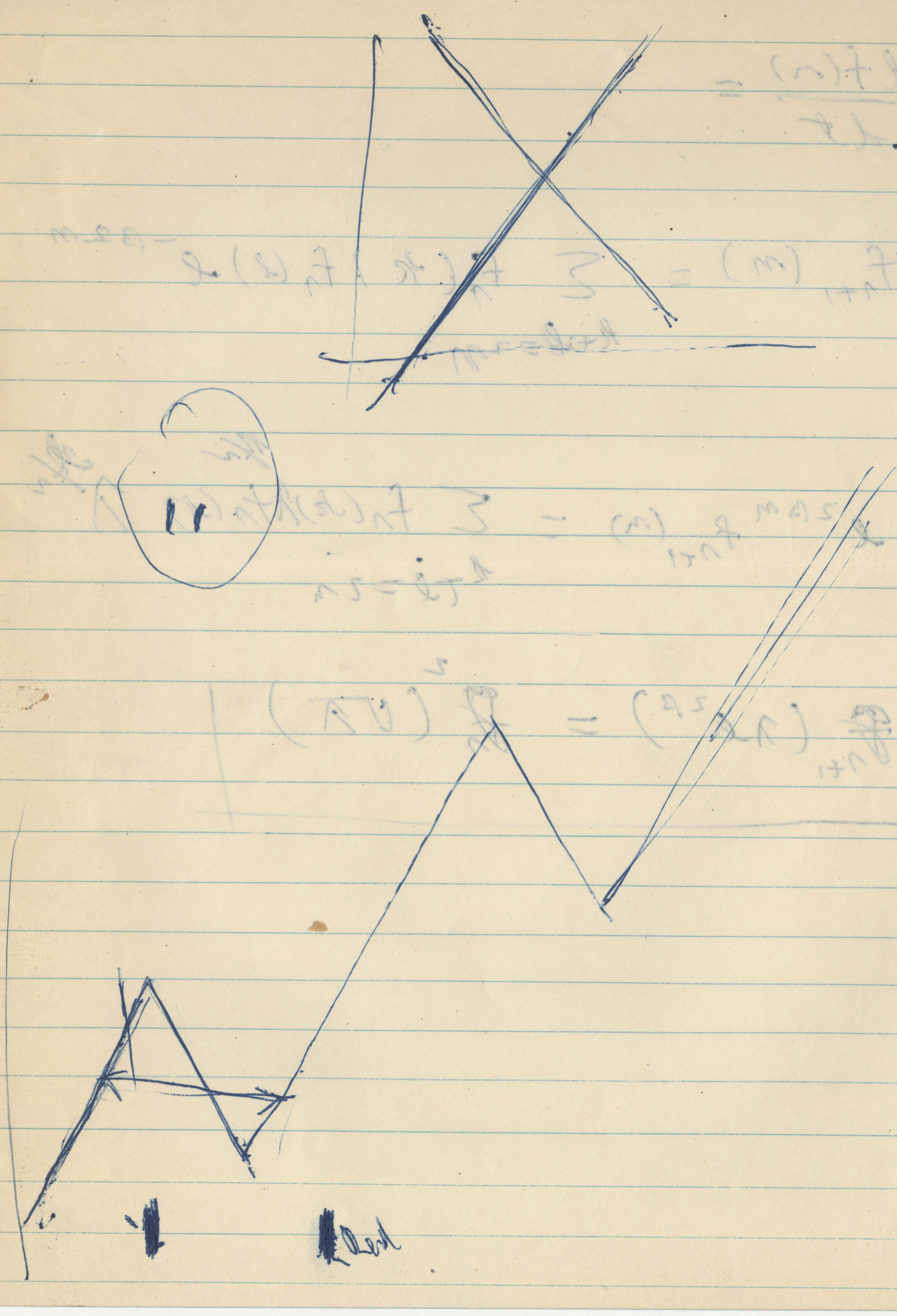
$$g_1(\lambda) g_1(\lambda) = g^2_1(\lambda)$$

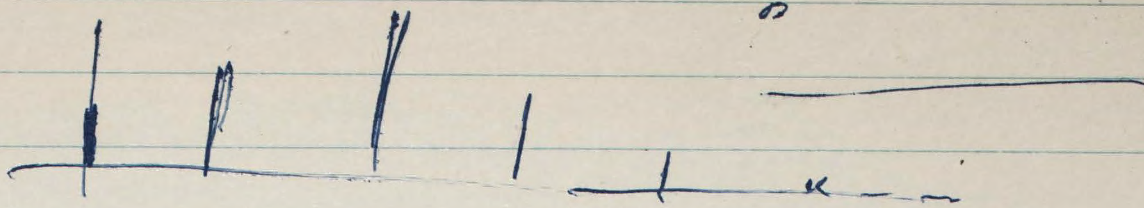
$$\frac{d f(n)}{dt} =$$

$$f_{\lambda+1}(n) = \sum_{k+l=2n} f_\lambda(k) f_\lambda(l) e^{-\beta 2 n}$$

$$\lambda^n e^{2\beta n} f_{\lambda+1}(n) = \sum_{k+l=2n} f_\lambda(k) \lambda^{k/2} f_\lambda(l) \lambda^{l/2}$$

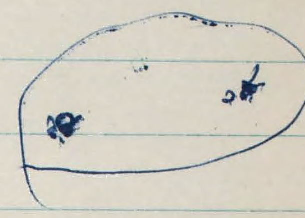
$$\boxed{\Phi_{\lambda+1}(\lambda e^{2\beta}) = \Phi_\lambda^2(\sqrt{\lambda})}$$





p_k

$$f(x) = \sum_0^\infty p_k x^k$$



$\boxed{f(x)}$

$$f(f(x)) = \sum_0^\infty p_k \left(\sum_0^\infty p_n x^n\right)^k$$

$g(x)$ $\qquad$ $f(x) = \sum p_k x^k$

$f(x)\, g(x)$ $\qquad$ $g(x) = \sum q_k x^k$

Other assumption

$$f(n) = \lambda e^{-n\beta} f(n-1)$$

$$f(n) = \frac{\lambda e^{-n\beta} f(n-1)}{\bar{a} - a_0 e^{-n\beta}}$$

$~~f(n) = \lambda e^{-n\beta}~~$

$\bar{a}$

a_0

λ

$$f(0), \quad \frac{f(0)\,\lambda e^{-\beta}}{\beta}, \quad \frac{f(0)(\lambda)^2 \left(e^{-\beta}\right) e^{-2\beta}}{\beta\, 2\beta}$$

$$\sum \frac{1}{n!} \frac{\lambda^n}{\beta^n} e^{-1+2+3+n}$$

Vague

Superthermostat

Incoming bacteria per sec. (w - n)
every bact. infected,

$e^{-W_2/V_2\,T}$ T_2 is latent period

$e^{-\frac{W_2}{V_2} L}$ will burst per sec. giving N phage particles

$$\frac{dn}{dt} = W n_0 N(c)\, e^{-\frac{W_2}{V_2} L(c)} + n\, \frac{W_2}{V_2}$$

$$\frac{dn}{dt} = W n_0 N(c)\, e^{-\frac{W_2}{V_2} L(c)} - n \frac{W_2}{V_2}$$

$$n = \frac{W n_0 N(c)\, e^{-\frac{W_2}{V_2} L(c)}}{\frac{W_2}{V_2}}$$

Free phage conc.

Free phage ads neglected

Dressler

②

Infectious centers n_2

$$\frac{dn_2}{dt} = -n_2\frac{W_2}{V_2} - \frac{W_0 n_0}{V_2} e^{-\frac{W_2}{V_2}L(c)} + \frac{n_0 W_0}{V_2}$$

$$n_2 = \left\{1 - e^{-\frac{W_2}{V_2}L(c)}\right\}\frac{n_0 W_0}{W_2}$$

for large V_2
small $W_2 L(c_2)$ $n_2 \approx L(c_2)\, n_0 W_0$

incoming from chemostat W_0, n_0, W_0 c

incoming from side branch, $W_2 - W_0$, $(W_2 - W_0)a_2$,

Tryptophane balance tryptophane c_2 conc

$$(W_2 - W_0)a_2 + W_0 c_0 = f(c_2)\, n_2 V_2 + W_2 c_2$$

$$f c_2 L_0 n_0 W_0 V_2 + W_2 c_2$$

$$\frac{(W_2 - W_0)}{W_2} a_2 + \frac{W_0 c_0}{W_2} = f L_0 n_0 \frac{W_0}{W_2} V_2 + c_2$$

is c enough for full phase output

c $= 10^{-9}$ gm bacterium $2\,10^{-15}$

$\underline{5}.10^{8} \times \underline{2}\, 10^{-15} = 10^{-6}$ gm/cc

gm/gm/vol sec/gm/vol

(vol)^2/sec gm

if phage 1% of tryptophane it takes

10 times c for full yield

Interesting case: slow flow $\frac{W_2}{V} \gg L$

and look for mutant/wildtype

Infectious centers n_2 (3)

$$(1) \qquad n_2 = \frac{n_0 w_0}{w_2}\left(1 - e^{-\frac{w_2}{V_2} L(c_2)}\right)$$

Pyrophosphate balance

$$(2) \qquad (w_2 - w_0)a_2 + w_0 c_0 = F(c_2)\, n_2 V_2 + w_2 c_2$$

gm/sec ~~cc/sec~~ $\cancel{\#/cc}$

~~from (1) $n_2 \approx$ ... $L(c_2)$ ... $n_0 w_0 \ell_0$~~

~~$(w_2 - w_0)a_2 + w_0 c_0 = f_0 c_2\, n_0 w_0 \frac{\ell_0}{c_2} \frac{c}{2} + w_2 c_2$~~

~~gm/sec~~ sec

~~$f_0 \ell_0$ should be of dim of $[c]$~~

~~f_0 gm/sec $[c]$ ℓ_0~~

from (1) $n_2 \approx \frac{n_0 w_0}{V_2} L(c_2)$

and (2) gives ~~now~~: ~~gm/sec~~ / ~~sec~~

$(w_2 - w_0)a_2 + w_0 c_0 \approx F(c)\, n_0 w_0 L(c_2) + w_2 c_2$

$\qquad f_0 \cancel{c_2}\, n_0 w_0 \frac{\ell_0}{\cancel{c_2}} + w_2 c_2$

$(w_2 - w_0)a_2 + w_0 c_0 \simeq f_0 \ell_0 n_0 w_0 + w_2 c_2$

$$(3) \qquad c_2 \approx \frac{w_2 - w_0}{w_2} a_2 + \frac{w_0}{w_2} c_0 - f_0 \ell_0 n_0 \frac{w_0}{w_2}$$

better ↓ ↓ ↓ ↓

if A is taken of ... per phage and phage yield is constant M
and if V_2 very large
$a(w_2 - w_0) + c_0 w_0$ is coming in; $AM n_0 w_0$ is taken up; $c_2 w_2$ is leaving
$a(w_2 - w_0) + c_0 w_0 = AM n_0 w_0 + w_2 c_2$
for large V_2 so that no infective centers are washed out

~~What is wrong with the stable [illegible]?~~

(1) $\dfrac{d f(n)}{dt} = +\lambda_1 f(n-1) + a_0 f(n) e^{-\beta n} - \lambda_1 f(n)$.

(2.) $\dfrac{df(n)}{dt} = \bar{a} f(n)$

$$\bar{a} f(n) = \lambda_1 f(n-1) + a_0 e^{-\beta n} f(n) - \lambda_1 f(n)$$

$$f(n)\left(\bar{a} + \lambda_1 - a_0 e^{-\beta n}\right) = \lambda f(n-1)$$

(3) $f(n) = \dfrac{\lambda/a_0 \times f(n-1)}{\dfrac{\bar{a}}{a_0} + \dfrac{\lambda_1}{a_0} - e^{-\beta n}}$

$a_0 = 1$

$$f(n) = \frac{\lambda f(n-1)}{\bar{a} + \lambda - e^{\beta n}}$$

$$\bar{a} + \lambda \geq e^{-\beta}$$

$$\frac{d f(0)}{dt} = a_0 f(0) - \lambda f(0)$$

$$\bar{a} f(0) = a_0 f(0) - \lambda f(0)$$

$$\frac{\bar{a}}{a_0} = 1 - \frac{\lambda}{a_0}$$

(4) $f(n) = \dfrac{\frac{\lambda}{a_0} f(n-1)}{1 - e^{-\beta n}}$

$$\frac{\bar{a}}{a_0} + \frac{\lambda}{a_0} = 1$$

2 λ problem //

$$\frac{d f(n)}{dt} = \lambda_1 f(n-1) + \lambda_2 f(n-2) + a_0 e^{-\beta n} f(n) - (\lambda_1 + \lambda_2) f(n)$$

$$\frac{d f(n)}{dt} = \bar{a} f(n)$$

$$\left(\bar{a} + \lambda_1 + \lambda_2 - \bar{a} e^{-\beta n}\right) f(n) = \lambda_1 f(n-1) + \lambda_2 f(n-2)$$

$a_0 = 1$

$$f(n) = \frac{\lambda_1 f(n-1) + \lambda_2 f(n-2)}{\underbrace{\bar{a} + \lambda_1 + \lambda_2}_{1} - e^{-\beta n}}$$

$$f(n) = (\lambda_1 + \lambda_2)^n$$

$$f(n) = \frac{\lambda_1 (\lambda_1 + \lambda_2)^{n-1} + \lambda_2 (\lambda_1 + \lambda_2)^{n-2}}{\cancel{1 - e^{-\beta n}}}$$

$$\frac{d f(0)}{dt} = a_0 f(0) - (\lambda_1 + \lambda_2) f(0)$$

$$\bar{a} f(0) = a_0 - \lambda_1 + \lambda_2$$

$$\frac{\bar{a}}{a_0} = 1 - \frac{\lambda_1}{a_0} + \frac{\lambda_2}{a_0}$$

$$f(n) = \lambda_1 (\lambda_1 + \lambda_2)^{n-2} (\lambda_1 + \lambda_2) + \lambda_2 (\lambda_1 + \lambda_2)^{n-2}$$

$$(\lambda_1)^2 (\lambda_1 + \lambda_2)^{n-2} + \lambda_1 \lambda_2 (\lambda_1 + \lambda_2)^{n-2}$$

$$+ \lambda_2 (\lambda_1 + \lambda_2)^{n-2}$$

$$f(n) = \lambda_1 f(n-1) + \lambda_2 f(n-2) + \lambda_k f(n-k)$$

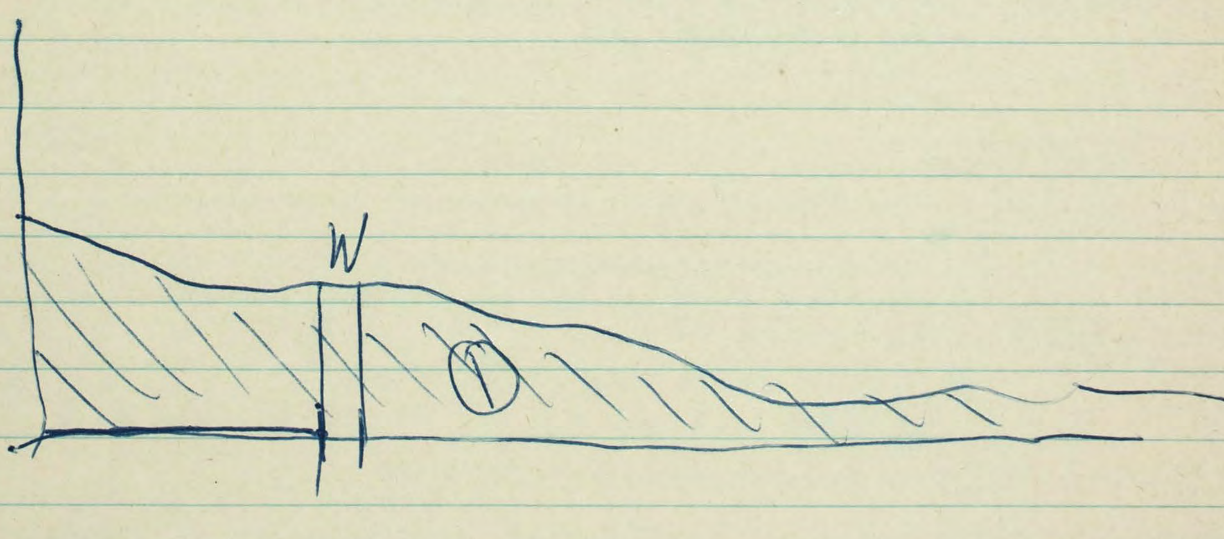
$$f(n) = k f(n-1)$$

$$f(n) = \frac{A(n)}{B(n)}$$

$$k^2 f(n-2) = \lambda_1 k f(n-2) + \lambda_2 f(n-2)$$

$$k^2 = \lambda_1 k + \lambda_2$$

$$1 = \lambda_1 + \lambda_2$$



Tryptophane ~~absorption~~ (4)

assume 10 Å square area 10^{-14} cm^2
each weighing ~~1000~~ $\frac{10^5 \times}{6\,10^{23}} = \frac{1}{6} 10^{-18}$ gm

~~1000~~ of bacterium ~~[illegible]~~ $\frac{10^{-12} \times \cancel{10^{-3}}}{\frac{1}{6} 10^{-18}} =$

~~$6000 \times 10^{-14} = 60 \times 10^{-12}$ cm^2 area~~

~~6000~~ $6\,10^6$ enzymes $\times 10^{-14}$ cm^2
$6 \times 10^6\, 10^{-14} = 6\,10^{-8}$ cm^2

$$10^{13} \left(e^{-\frac{E}{RT}}\right) \left(\frac{1}{a}\right)^{30} \approx 1000$$

$$60 \times \cancel{[illegible]} \times 2\,10^4 \left(\frac{1}{a}\right)^{30} = 1000$$

$60 \times$

Terphenol ~~[illegible]~~ dissolved in ~~Xylene~~ Toluene
5% Hofstetter

NaI (Harshaw) for γ rays

Frisch (Grand Central)

Frisch - Peierls fall of France (no measurement) after that: measurement in May Birmingham
& not in Liverpool. - Peierls -
Peierls - Adman

!! Estes Park !!

$$f(n) = \frac{\alpha}{\bar{\alpha} - \alpha_0 e^{-\beta n}} f(n-1)$$

$\{n - 1 \geqq 0\}$ $\quad$ $[\bar{\alpha} > \alpha_0 e^{-\beta}]$

$$f(n) > \frac{\alpha/\alpha_0}{(1 - e^{-\beta n})} f(n-1)$$

for small βn (also true but large βn ?) $\quad$ $\beta n > 1 - e^{-\beta n}$

$$f(n) > \frac{\alpha/\alpha_0}{\beta n} f(n-1)$$

$$\frac{\bar{\alpha}}{\alpha_0} < \frac{f(0) + f(1) e^{-\beta} + f_2 e^{-2\beta}}{f_0 + f(1) + f(2) + \cdots}$$

$$f(1) = \frac{\alpha/\alpha_0}{\beta} f_0$$

$$f(2) = \frac{(\alpha/\alpha_0)^2}{\cancel{\beta \cdot 2\beta}\; 2(\beta)^2} f_0$$

$$f(3) = \frac{(\alpha/\alpha_0)^3}{3!(\beta)^3} f_0$$

$$\frac{f(n)}{f(0)} = \frac{1}{n!} \frac{(\alpha/\alpha_0)^n}{\beta^n}$$

$$\frac{\bar{\alpha}}{\alpha_0} < \frac{e^{\alpha/\alpha_0\beta \cdot e^{-\beta}}}{\sum_0^\infty \frac{1}{n!}\left(\frac{\alpha/\alpha_0}{\beta}\right)^n = e^{\alpha/\alpha_0\beta}}$$

$$\frac{\bar{\alpha}}{\alpha_0} < e^{-\alpha/\alpha_0} \qquad \frac{\alpha}{e^{\beta}} \qquad e^{\frac{\alpha}{\alpha_0\beta}(1-\beta)}$$

$$e^{-\alpha/\alpha_0} > e^{-\beta} \qquad \frac{\alpha}{\alpha_0} < \beta$$

(2)

Man ~~ee~~ 30 WE 1 day

$\frac{30}{24}$ WE / day kg $\approx$ 1.2 kg / hour

Man or per hour and kg $\frac{\beta}{5\times 24} \approx \frac{1}{50}$ WA

Bacteria 4000 WE / kg hour

factor Man to bacteria about 3500

or $\frac{1}{10}$ of a day in bacteria = 1 year in

Man :— 2.4 hours or $\alpha \approx \frac{1}{2}\alpha_0$

Repeat from scratch

Population $N = f(0) + f(1) + f(2) + \dots f(n) + \dots$

$$\bar{a} = \frac{1}{N}\frac{dN}{dt} \quad \text{or} \quad \frac{dN}{dt} = \bar{a}N \qquad (1)$$

~~In the stationary~~

from the rate of bacteria containing

n mutations $\alpha(n) = \alpha_0 e^{-\beta n}$ (2)

Stationary state : $\frac{df(n)}{dt} = \bar{a}\, f(n)$ (3)

But $\frac{df(n)}{dt} = \alpha\, f(n-1) + \alpha_0 e^{-\beta n} f(n)$ (4)

from (3) and (4) we obtain

$$\bar{a}\, f(n) = a_0 e^{-\beta} f(n) + \alpha\, f(n-1)$$

$$f(n) = \frac{\alpha\, f(n-1)}{\bar{\alpha} - \alpha_0 e^{-\beta n}} = \frac{\alpha/\alpha_0\, f(n-1)}{\bar{\alpha}/\alpha_0 - e^{-\beta n}} \qquad (5)$$

Since f must be positive and finite for

all $n \geqq 1$ $\quad \bar{\alpha} > \alpha_0 e^{-\beta}$; $\frac{\bar{\alpha}}{\alpha_0} > e^{-\beta}$ (6)

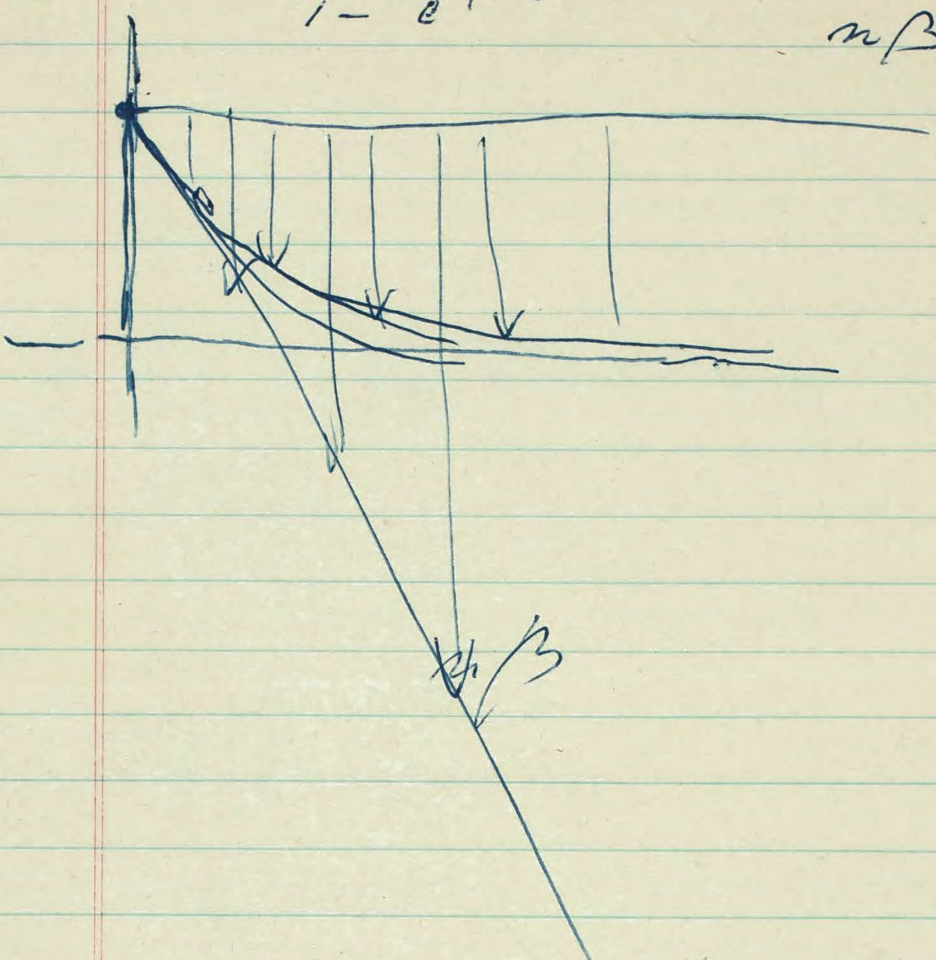
(3)

From (5) we obtain since $\frac{\bar{\alpha}}{\alpha_0} < 1$

$$f(n) > \frac{1/\alpha_0 f(n-1)}{1 - e^{-\beta n}}$$

and we further obtain, since $n\beta > 1 - e^{-\beta n}$

(7) $$f(n) > \frac{1/\alpha_0 f(n-1)}{1 - e^{-\beta n}} > \frac{1/\alpha_0 \times f(n-1)}{n\beta} = f^*(n)$$



$f(n) = f^*(n) + \Delta(n)$ where $\Delta(n) > 0$

(8) $$\bar{\alpha} = \alpha_0 \frac{f(0) + f(1)e^{-\beta} + f(2)e^{-2\beta} + \ldots f(n)e^{-\beta n}}{f(0) + f(1) + f(2) + \ldots f(n)}$$

~~Now if $f^* < f$~~

$a = \frac{\cancel{C A B} \cdot \epsilon}{A + B}$

$a = \frac{\text{Const}_0 + A\,\epsilon}{\text{Const} + A}$

Now if $f^* < f$ so that

$$f(n) = f^*(n) + \Delta(n) \text{ (positive)}$$

from (8)

$$\frac{\bar{\alpha}}{\alpha_0} = \frac{f(0) + f(1)e^{-\beta} + \ldots (f^*(n) + \Delta n)e^{-\beta n} + \ldots}{f(0) + f(1) + + \ldots f^*(n) + \Delta(n) + \ldots}$$

We can now show that (4)

$$\frac{\bar{\alpha}}{\alpha_0} \leqq \frac{f(0) + f(1)e^{-\beta} + f(2)e^{-2\beta} + \dots f^*(n)e^{-n\beta} + \dots}{f(0) + f(1) + f(2) + \dots f^*(n) + \dots}$$

In order to show that we write

(9) $$\frac{\bar{\alpha}}{\alpha_0} = \frac{A(n) + \cancel{\dots} + \Delta(n)e^{-n\beta}}{B(n)\cancel{\dots} + \Delta(n)} \leqq \frac{A(n)}{B(n)}$$

and have then to show that

$$\frac{A(n)}{B(n)} - \frac{A(n) + \Delta(n)e^{-n\beta}}{B(n) + \Delta(n)} \geqq 0$$

or $\cancel{AB} + A\,\Delta(n) - \cancel{BA} - B\Delta(n)e^{-n\beta} > 0$

(10) $$A(n) - B(n)e^{-n\beta} \geqq 0$$

or $A(n) > B(n)e^{-n\beta}$

In order to see that we write for (6) $\frac{\bar{\alpha}}{\alpha_0} > e^{-\beta}$ from (9)

$$\frac{A(n) + \Delta(n)e^{-n\beta}}{B(n) + \Delta(n)} > e^{-\beta}$$

(11) or $A + \Delta(n)e^{-n\beta} - B(n)e^{-\beta} - \Delta(n)e^{-\beta} > 0$

or ~~...~~ $A - B(n)e^{-\beta} > \Delta(n)e^{-\beta} - \Delta(n)e^{-n\beta}$

or $A - B(n)e^{-\beta} > 0$

or $A > B(n)e^{-\beta}$

but since $B(n)e^{-\beta} > B(n)e^{-n\beta}$

we have $A > B(n)e^{-n\beta}$

which is identical with (10)

We may therefore write

$$\frac{\bar{\alpha}}{\alpha_0} \leqq \frac{f^*(0) + f^*(1)e^{-\beta} + f^*(2)e^{-2\beta} + \dots f^*(n)e^{-n\beta} + \dots}{f^*(0) + f^*(1) + f^*(2) + \dots f^*(n)}$$

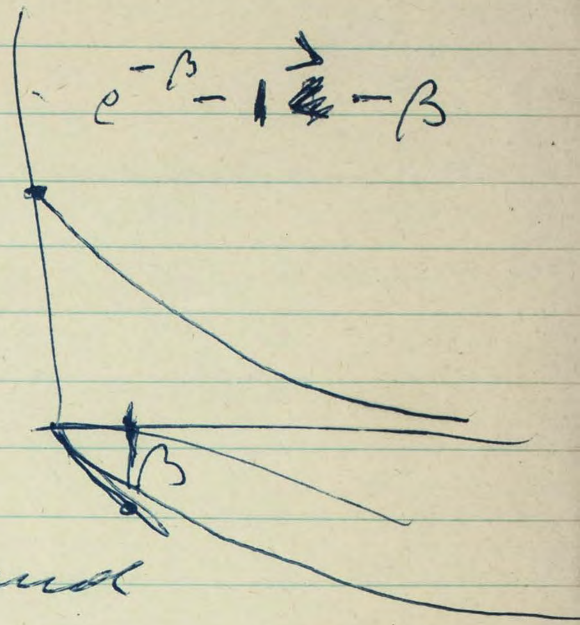
5

and from (7)

$$\frac{\bar{\lambda}}{\alpha_0} \leqq \frac{1 + \frac{\lambda/\alpha_0}{\beta} e^{-\beta} + \frac{(\lambda/\alpha_0)^2}{1.2\beta^2} e^{-2\beta} + \dots \frac{(\lambda/\alpha_0)^n}{n!\,\beta^n} e^{-n\beta}}{1 + \frac{\lambda/\alpha_0}{\beta} + \frac{\lambda/\alpha_0}{1.2\beta^2} + \dots \frac{(\lambda/\alpha)^n}{n!\,\beta^n}}$$

$$= \frac{e^{\frac{\lambda/\alpha_0}{\beta} e^{-\beta}}}{e^{\frac{\lambda/\alpha_0}{\beta}}} = e^{\frac{\lambda/\alpha_0}{\beta}[e^{-\beta} - 1]}$$

$$= e^{\lambda/\alpha_0\beta \times [e^{-\beta} - 1]}$$



or for small β

(12) $$\frac{\bar{\lambda}}{\alpha_0} \leqq e^{-\frac{\lambda}{\alpha_0}}$$

But on the other hand from (6) $$\frac{\bar{\lambda}}{\alpha_0} > e^{-\beta}$$

thus from (6) and (12)

$$e^{-\beta} \leqq e^{-\frac{\lambda}{\alpha_0}}$$

or

(13) $$\frac{\lambda}{\alpha_0} < \beta$$

~~which~~

for any β we must have from (5) for large n and m

$$f(n) = \left(\frac{\lambda}{\bar{\lambda}}\right)^{n-m} f(m)$$

so it must be $\frac{\lambda}{\bar{\lambda}} < 1$

(14) or $\lambda < \bar{\lambda} < \alpha_0$

or $\frac{\lambda}{\alpha_0} < 1$